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Maintenance of Seed Viability and Vigour in Vegetable Seeds

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Seed viability and vigour are critical determinants of germination, emergence, and long-term plant survival, especially under variable environmental and storage conditions. This article explores how seed performance is influenced by genetic, environmental, and storage factors, emphasizing the importance of seed banks in plant community regeneration and biodiversity conservation. It also highlights testing methods for viability and vigour, and the impact of physiological and biochemical seed ageing on seed quality. Understanding and managing these factors is essential for effective seed conservation, agriculture, and ecological restoration efforts.

Introduction

The field emergence of high germinating seed lots can vary considerably when sowing at the same time in the same field, as well as their performance after storage or transportation to the same destination. Understanding how communities function in a stable or changing environment depends on knowing the number and quality of viable seeds in tundra soils. This includes seedlings, juveniles, and adult populations from this seed bank. The performance of seeds is greatly dependent on the storage conditions and genetic factors. Seed longevity, viability and vigour depend not only on the storage conditions but also on quality. It is important to note that temperature, moisture, seed characteristics, microorganism geographic location, and storage structure have significant influences on storage. Increasing the viability of seeds by storing them cold or dry with seed moisture less than 5% will increase their viability and lengthen their lifetime. Germination behaviour (i.e., the time and pattern of germination, as well as the lifespan of viable seed in the soil) is significant even in perennial plants since seedlings are more vulnerable to control approaches than mature plants and thus make better targets in any weed management scheme. Buried viable seed banks are a key part of seed plant biology, as they aid in the conservation and regeneration of plant communities and serve as predictors of plant response to changes in land use and climate (Thompson *et al.*, 1997).

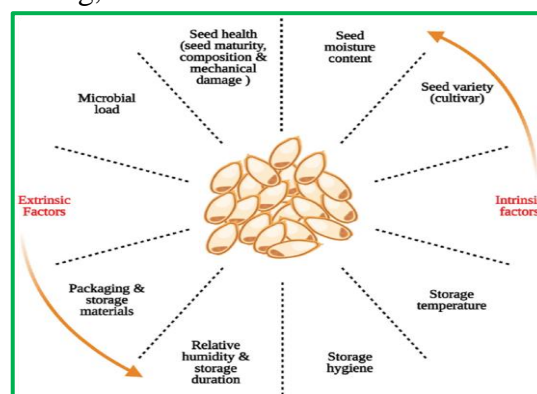
Seed Viability

Seed viability refers to the embryo's capacity to germinate and is influenced by a variety of factors. Seed viability is affected by a number of factors, including the plant's ability to produce viable seeds, predator and disease damage, and environmental circumstances such as flooding or heat. The health and germination capacity of a seed are also affected by its age. Seeds are living embryos, and cells die and cannot be replenished over time. Both genetics and the environment can determine how long a seed remains viable. Some seeds can live for several years in ideal conditions, whereas others can only live for a seasonal cycle. Seed viability is very important for sectors that rely on seeds. Seed viability is especially important in businesses that rely on germinating seeds, such as forestry and agriculture. Predicting seed viability is an important element of the planning process because it ensures that resources are spent appropriately. Seed viability can be predicted using two approaches. The first approach is based on a visual evaluation of seed quality, while the second method predicts viability based on the germination of a sample population of seeds. Seed Vigour: The sum total of those features of the seed that determine the level of activity and performance of the seed in a seed lot during germination and seedling emergence.

Seed Viability Vegetables & Cover Crops			
Type	Years	Type	Years
Alfalfa	5	Cucumber	6
Artichoke & Cardoon	4	Dandelion	2
Arugula	6	Eggplant	5
Asian Greens	3	Endive/Escarole	5
Asparagus	4	Fennel	4
Barley	5	Kale	5
Beans	4	Kohlrabi	5
Beets	5	Leeks	3
Broccoli	5	Lentil	2
		Rhubarb	2
		Rutabaga	5
		Rye	3
		Salsify	2
		Sorghum	2
		Soybean	5
		Spinach	5
		Squash & Gourds	6
		Strawberry	5

Seed vigour

Loss is linked to a decrease in the ability of seeds to carry out all of the physiological tasks that allow them to operate in any seed lot. Physiological ageing (or degeneration) begins prior to harvest and continues throughout harvest, processing, and storage. Changes in cell membrane integrity, enzyme activity, and protein synthesis, for example, gradually impair performance capacities. These biochemical changes can happen swiftly (in a matter of days) or slowly (in years), depending on genetic, manufacturing, and environmental factors that are still unknown. The seed will eventually die as a result of this degradation (i.e. complete loss of germination). Seeds, on the other hand, lose their vigour before they lose their capacity to germinate. That's why seed lots with similar high germination rates might differ in physiological age (the level of degeneration) and, as a result, in seed vigour and hence performance. Seed lots of agricultural, horticultural, and silvicultural species have varying levels of seed vigour. (ISTA, 2009).



Studies in Seed Bank

Seed banks have solely recently been integrated into demographic models of plant populations. This can be, in all probability, the result of seed bank information (e.g. seed survival and germination rates) is often harder to gather than data from adult plants.

Furthermore, gamete banks are terribly totally different in composition, duration, and useful importance. Thompson and Grime (1979) classified seed banks into four types, distinctive between transient and chronic seed banks. They outlined transient seed banks as those with non-viable seeds that existed for over a year and persistent seed banks as those with viable seeds that persisted for extended periods. In theoretical studies, the possible contributions of transitory and permanent seed banks to population long-term survival and viability have been considered (Cohen, 1966). Buried viable seed banks are a key part of seed plant biology, as they aid in the conservation and regeneration of plant communities and serve as predictors of plant response to changes in land use and climate (Thompson *et al.*, 1997). The species makeup of the seed bank gives an indication of the type of community that can emerge, depending on environmental changes at the sites (Richtner & Stronberg, 2005). Ground vegetation restoration can take place in a variety of ways: Planting of the missing herbaceous species, natural colonization from surrounding native woods, and natural colonization by the seed bank are all possibilities. The first option is far too costly to be generally adopted. Similarly, soil colonization from a neighboring forest can be sluggish and impossible if there is no native forest in the area under consideration. Seed banks could play a significant role in this instance (Augusto *et al.*, 2001) since they would be a primary source of vegetation regeneration in areas where disturbance is common (Richtner & Stronberg, 2005).

Seed Bank Viability

The importance of seed banks in sustaining populations of habitat-forming seagrasses and other submerged aquatic vegetation species is growing (McMillan, 1991). In terrestrial plant communities, the usefulness of viable seed banks as "buffers" against variability and disturbance has been intensively studied, and it is widely acknowledged as an important approach in post-stress regeneration of habitat-forming vegetation (Middleton, 1991). In hydrologically changeable habitats such as seasonal floodplains, marshes, and wetlands, seed recruitment is also crucial in defining vegetation composition (Leck and Brock, 2000). In situ germination during the spring and summer contributed to the decline in viable seeds buried at non-deep conditions. The appearance of dead seedlings upon seed recovery revealed this. With seeds buried deep in the condition, some in situ germination occurred, but the percentage was substantially lower. Seed deterioration was the main cause of the decline in viable seed of deeply buried red rice and commercial Rice Seeds.

Effect of Storage on Viability and Vigour

In agriculture, the highest seed yield was reached under normal nutrition and climatic circumstances (Beyranvand *et al.*, 2013). Seed quality and, ultimately, seed yield after cultivation were altered by storage conditions. Seed lots' storage potential is determined by the level of deterioration (vigour status) at the time of storage. If the storage environment is stressed in any way (e.g., temperature or relative humidity variations in unmanaged storage), high vigour seed lots will be able to tolerate the stress and will lose quality at a slower rate than lower vigour seed lots. The vigour level of the seed lot determines performance after storage, even under controlled storage circumstances (low temperature and low seed moisture content) (ISTA, 2009). Because various physiological and biochemical processes and products are regulated during dry storage, the use of hermetically sealed containers, desiccants, and low temperatures increases storability. Seeds that have been exposed to high temperatures and humidity for several days have been acknowledged as an accurate indicator of seed viability and storability (Delouche and Baskin, 1973).

Damages to membranes, nucleic acids, and proteins are related to some of the negative impacts of ageing (Fujikura and Karssen, 1995). Standardization of seed conditioning, packaging, and storage conditions could ensure that onion seeds are planted in good condition at the time of sowing. Confounding environmental and biological factors determine the rate of seed degradation. Seed degradation is accelerated by high storage temperatures and high seed moisture content (McDonald, 1999). Seed moisture content and temperature have different effects on seed lifetime depending on species and seed structural

and biochemical composition. Based on seed moisture and storage temperature, a complete pattern of viability loss could be deduced (Ellis *et al.*, 1982). Under sub-tropical Indian circumstances, drastic variations, as well as high humidity and temperatures, exacerbate the loss of germination in stored onion seeds. At the worldwide level, genetic degradation of material kept in gene banks is seen as a serious issue (FAO, 1997). As a result, it is strongly advised that the key mechanisms producing genetic erosion in ex situ collections be monitored to prevent the loss of genetic diversity. Low quality of the original material, over drying of seed before storage, increase in temperature or moisture content of seed during preservation, lack of regeneration, losses of germplasm during multiplication, physiological changes in seed during storage, and no detectable loss of germination due to a lack of viability monitoring are some of these factors (FAO, 1997). In general, a moisture content of 37 percent and a storage temperature below 8 degrees Celsius would allow for long-term seed preservation (FAO/IPGRI, 1994). However, even if the seed is stored in controlled circumstances, viability may suffer as a result of degradation.

Testing Seed Vigour

The standard germination test is a seed quality indicator that can be used to forecast field emergence if soil conditions are close to optimal. However, the conditions under which the seed is discovered during examination frequently differ from those in the field. Seed viability affects germination in the field. Seed viability, also known as seed vigour, is a set of qualities that determines the activity and behaviour of commercially viable seed germination seed lots in various environmental conditions. In addition to the foregoing, the seed vigour determines the seed's longevity with no negative consequences (ISTA, 2009). Various vigour tests are utilised to gain more specific information about the seed lot's quality. Testing seed viability using various seed vigour tests is important because vigour tests frequently produce findings that are more closely connected with the outcomes of field germination under adverse conditions than the results obtained by using a standard laboratory germination test. The vigour tests were divided into three categories by McDonald (1975): Seed parameters like as size and bulk are determined by physical examinations. These assays are low-cost, fast, and may be used on a large number of samples. They also have a favourable correlation with seed vigour. The accumulation of nutritive elements is the most important feature of seed growth, and it is also linked to vigour, or seed size and mass. Germination and growth characteristics are used in physiological examinations. These tests are divided into two categories. The first type occurs when germination takes place under favourable conditions (standard laboratory germination and test of growth intensity). When a seed is subjected to unfavourable environmental conditions, the second type occurs (cold test, accelerated ageing test, and Hiltner test). Biochemical assays are regarded as indirect ways of determining the value of seeds. Tetrazolium test, conduct metric measures, enzyme activity, and respiration are examples of these.

Testing Seed Viability

Regular physiological, biochemical, and more recently molecular examinations of seed material should provide insight into the quality and provide a firm basis for improving breeding programmes and enhancing control systems in the seed production process (Miloevic *et al.*, 2007). One of the secondary duties in the production of a grain crop is seed viability testing (germination). Nonetheless, it necessitates close scrutiny. Without knowing the germination potential of the seed to be planted, an educated calculation of the number of seeds required to provide an acceptable population of plants at the start of the planting cycle will be impossible. The percentage of seeds that germinate in a sample collected from seeds that will be planted is an important test, but it isn't enough. Another aspect to consider in this activity is the plant's vitality. The ability for the plantlets to establish and grow well is referred to as vigour. Seed physiology, as evaluated by an emergence test, is insufficient to predict seed storage potential. Cho and Sanders used tetrazolium dye to test the viability of embryos from undamaged seeds (2009). To summarise, entire seeds were steeped in water

overnight to weaken the seed coverings, which were then gently removed with a scalpel under a dissection microscope. Embryos were immersed in the dye solution (5 per cent, w/v) in the dark for a minimum of 24 hours after the seed coats were removed. Nonviable embryos were left white, whereas healthy embryos were coloured red. Seeds with a V-shaped opening were separated from those with pieces identifiable by an attached pedicel.

Conclusion

The longevity, viability, and vigour of seeds are crucial elements that determine not only successful germination and crop productivity but also the regeneration and sustainability of natural plant communities. As this article highlights, seed performance is influenced by a complex interplay of genetic factors, environmental conditions, and especially storage practices. Inappropriate storage can accelerate seed deterioration, while proper management—such as low-temperature and low-moisture environments—can significantly extend seed life. The role of seed banks is especially important in conserving genetic diversity, supporting habitat restoration, and serving as buffers against environmental disturbances and climate change. Vigour and viability tests are indispensable tools for assessing seed quality more accurately than standard germination tests alone, especially under suboptimal conditions. To ensure long-term agricultural productivity, ecological restoration, and biodiversity conservation, it is imperative to adopt integrated strategies for seed storage, handling, and testing, backed by ongoing scientific research and monitoring.

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